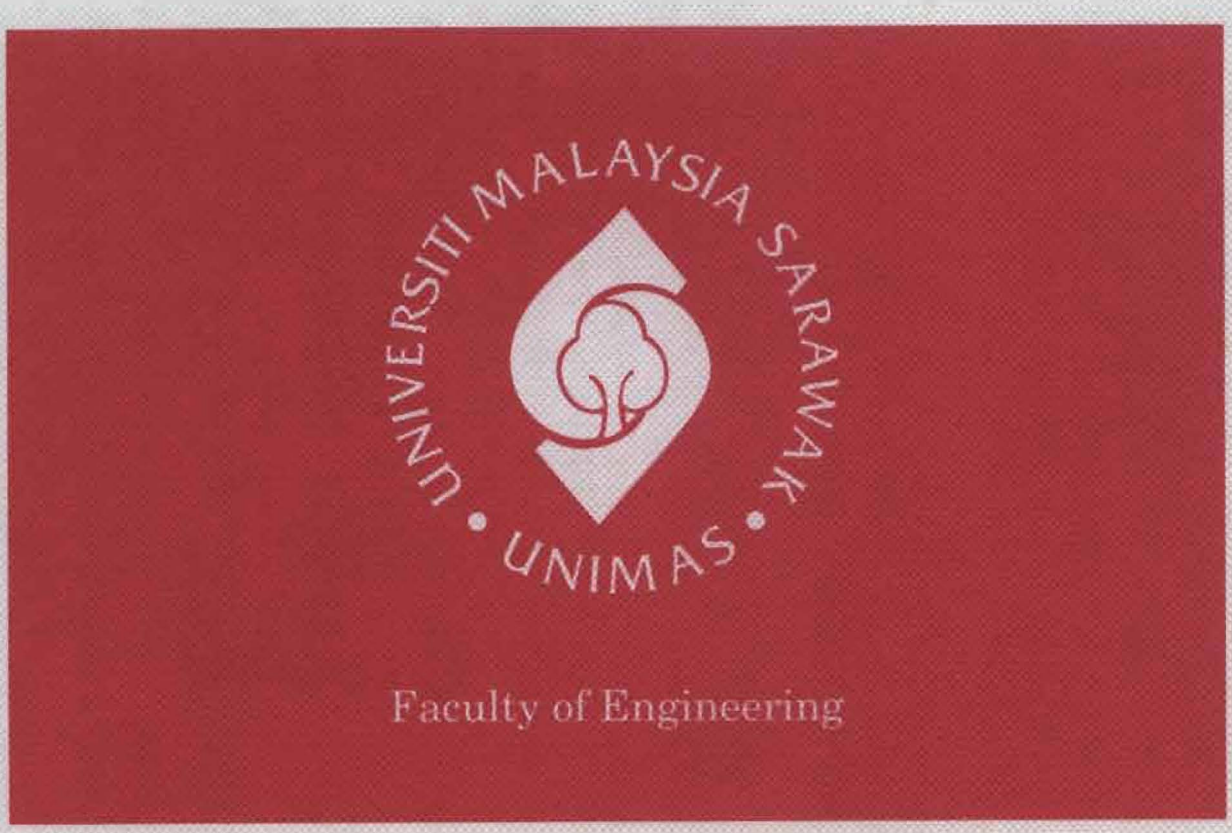

PHYSICAL AND CHEMICAL CHARACTERISTICS OF TROPICAL PEATS - A REVIEW

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Bachelor of Engineering with Honours
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PHYSICAL AND CHEMICAL CHARACTERISTICS OF TROPICAL PEAT - A REVIEW

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This report is submitted in partial fulfillment of the requirements for the degree of Bachelor of Engineering with Honours

(Civil Engineering)

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2009

DEDICATED TO MY BELOVED FAMILY AND FRIENDS

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ABSTRAK

Tanah gambut terhasil daripada pengumpulan bahan organik yang telah reput. (Contohnya, sisa tumbuhan dan bangkai haiwan). Tetapi, ia lebih kepada hasil pereputan sisa tumbuhan. Kertas kerja ini membentangkan tentang ciri-ciri tanah gambut dari segi fizikal dan kimia. Ia akan meliputi kawasan tropika di seluruh dunia. Segala analisis adalah berdasarkan penyelidikan yang telah dibuat. Data-data yang digunakan telah dikumpul melalui pelbagai sumber. Kajian ke atas ciri-ciri fizikal tanah gambut adalah lebih tertumpu pada mekanik tanah dan kejuruteraan tanah berbanding dengan kimia tanah. Ciri-ciri kimia pula lebih tertumpu pada komposisi kimia asas. Kajian ini telah dijalankan dengan melakukan penyelidikan melalui internet, buku, jurnal, majalah dan lain - lain. Selepas itu, semua data dikategorikan kepada dua bahagian iaitu ciri – cirri fizikal dan kimia. Kajian telah menunjukkan kandungan air di dalam *fibric* lebih tinggi berbanding *sapric*. *Fibric* juga mempunyai nilai *hydraulic conductivity* yang tinggi. Kajian juga telah menunjukkan *bulk density* boleh dipengaruhi oleh iklim, tinggi paras air, dan pengoksidaan. Kehadiran komposisi organik di dalam tanah gambut telah mempengaruhi nilai pH.

ABSTRACT

Peat is formed by the accumulation of organic matter derived mainly from dead vegetation in situations where decomposition (i.e., the breaking down of plant and animal material) is limited. But, they mainly formed from the undecomposed remains of rain forest trees. This paper describes the physical and chemical characteristics of tropical peat. It covered mostly the tropics areas in the worldwide. All the analysis done by gets through others research. The data are collected from various types of sources. Study of physical properties was more the domain of soil mechanics and soil engineering than of soil chemistry. The chemical properties concentrate on basic chemical composition when it is of importance for a better understanding. The study carried out by doing some research through internets, books, journal, magazines and etc. After that, all the data analyzed by separated them into two categories which are physical and chemical characteristics. The study shows that water content in fibric materials always appears to be appreciably higher than sapric material. Fibric materials also have exhibit high hydraulic conductivity. The study also shows that bulk density can be affected by climate, height of water table and oxidation. Presence of organic compound in the tropical peat had affected the pH value.

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SD - Specific bulk density

BD - Non-specific bulk density

CHAPTER 1

INTRODUCTION

1.1 Background

Tropical peat are found mostly in South East Asia (about 70% by area) although are also found in Africa, Central and South America and elsewhere around the Pacific Ocean. Tropical peat lands are significant carbon sinks and contains large amount of carbon and their destruction can significantly impact on the amount of atmospheric carbon dioxide. They are also vulnerable to destabilization through human and climate induced changes. Estimates of the area (and hence volume) of tropical peat lands vary but we should choose a reasonable estimate which is in the region of 380,000 square kilometers. Although tropical peat lands only cover about ¼% of the Earth's land surface, they contain 50,000-70,000 million tones of carbon (about 3% global soil carbon).

Peat soils are generally considered as problematic soil in any construction projects because of its high compressibility and very low shear strength. With the rapid industrialization and population growth, construction is scheduled almost everywhere including peat-land area. With respect to construction on soft-soils, selection of an appropriate method is governed by a number of factors such as:

- Type and classification of roads
- Design settlement criteria imposed
- Type and thickness of peat deposits
- Time and adequate fill material sources availability for construction
- Availability of monetary fund allocated for the project

1.2 Scope of Work

The Tropics are centered on the equator and limited in latitude by the Tropic of Cancer in the northern hemisphere, at approximately 23°26' (23.4°) N latitude, and the Tropic of Capricorn in the southern hemisphere at 23°26' (23.4°) S latitude. This region is also referred to as the tropical zone and the Torrid Zone (refer to Figure 1). On the other hand, in the temperate zones, north of the Tropic of Cancer and south of the Tropic of Capricorn, the sun never reaches the zenith, always passing south of it in the northern hemisphere, and north of it in the southern.

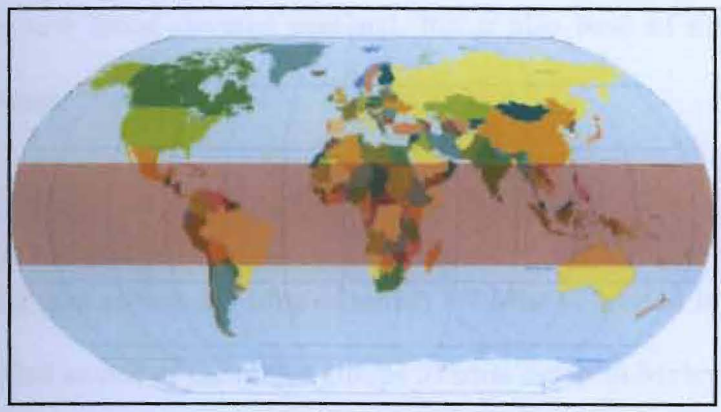

Figure 1.1: World map with the tropics highlighted in red

This research will be base on tropical peat in the worldwide. But, it may focus more in the South East Asia especially for Malaysia. This type of land (tropical peat) land is different from other wetland due to their formation. It depends on the types of plant which the peats are formed. As for tropical peat land, they formed mainly from undecomposed of remaining rainforest trees. It also due to the difference of rainfall condition (high rainfall), high evapotranspiration, and very high mean annual temperatures in tropical areas. It means that tropical peat categorized as organic soils in the wetlands of tropical and sub-tropical area, which the mean annual soil temperature is 22°C or higher.

Tropical peatland, one of the least known ecosystems of the world covers between 30 and 45 Mha, which is approximately 12% of the global peatland resource by area. Brunei, Indonesia and Malaysia contain nearly 70% of the total resource while the island of Borneo has about one quarter of the total (11 Mha). Indonesia contains the largest area of peat in the tropical zone with estimates ranging from 16 to 27 Mha. Central Kalimantan province (Indonesia) has still approximately 3 Mha of

largely tropical rain forest covered peatland, but is also base of many failed peat conversion projects.

In Malaysia peat covers 2.7 Mha of which 1.7 Mha is located in Sarawak. Peat has been identified as one of the major groups of soils found in Malaysia. 3.0 million hectares or 8% of the area is covered with peat. On the west coast of Malaysian Peninsular, the deposits are formed in depressions consisting predominantly of marine clay deposits or a mixture of marine and river deposits especially in areas along river courses. There are two types of peat deposit, the shallow deposit usually less than 3 m thick while the thickness of deep peat deposit in Malaysia exceeds 5 m. Currently the utilisation of peat land in Malaysia is quite low although construction on marginal land such as peat has become increasingly necessary for economic reasons. Engineers are reluctant to construct on peat because of difficulty to access the site and other problems related to unique characteristics of peat. Thus, not much research has been focused on the behaviour of peat and the development of soil improvement method for construction on peat soil.

1.3 Objectives

The objective of this research is to determine the physical and chemical characteristics of the tropical peat. The physical characteristics are more concerning about water management purposes and the behavior of tropical peat. There are consist four material which are mineral material, organic material, water and air. For

example, it may consist of moisture relationship, bulk density, texture, swelling and shrinking, and porosity.

Tropical peats have their own characteristics, similar to the other type of soil. Their characteristic categorized into two parts. There are chemical and physical characteristic. This type of soil or land has different characteristics from others which will be discuss later.

Chemical characteristics of tropical peat are mainly about the compound organic constituents and the elemental composition, than on derived chemical properties such as exchange characteristics. This research will only concentrate on basic chemical composition because it will easier to understand.

At the end of this research (Chapter 5), we will be able to identify the characteristics of tropical peat land, basically for both of physical and chemical. From these, we can do a better management of tropical peats and maybe able use to solve the problems regarding on this type of land.

The literature review for this research will be discuss in the Chapter 2, and the Chapter 3 will be discuss about the method of finding the information about tropical peat. Chapter 4, 5 and, 6 will be focus on data and analysis, discussion and conclusions respectively.

CHAPTER 2

LITERATURE REVIEW

2.1 General Condition of Tropical Peat

Tropical peat is one of the types of soil. This tropical peat is categorized as difficult soil. It means that tropical peat is not quiet suitable for construction. The categories are based on the soil color, soil structure, and texture. Soil color results from chemical and biological weathering. As the primary minerals in parent material weather, the elements combine into new and colorful compounds. Iron forms secondary minerals with a yellow or red color; organic matter decomposes into brown compounds; and manganese, sulfur and nitrogen can form black mineral deposits. Soil structure is the arrangement of soil particles into aggregates. These may have various shapes, sizes and degrees of development or expression. Soil texture refers to sand, silt and clay composition. Sand and silt is the product of physical weathering while clay is the product of chemical weathering. Clay content is particularly influential on soil behavior due to a high retention capacity for nutrients and water.

Study conducted by Andriesse (1988) revealed that the bearing capacity of peat soil was very low and was apparently influenced by the water table and the presence of subsurface woody debris. Peat poses serious problems in construction industry due to its long-term consolidation settlements even when subjected to a moderate load. Hence, peat is considered as unsuitable for supporting foundations in its natural state.

According to Jamil et al. (1989) where soil with peat depth of <1.0 m, 1.0 – 1.5 m, 1.5 – 3.0 m, and >3.0 m is classified as shallow, moderate, deep and very deep peat. Soil fabric, characterized by organic coarse particles, holds a considerable amount of water because the coarse particles are generally very loose, and the organic particle itself is hollow and largely full of water. The water content of peat researched in West Malaysia ranges from 200 to 700% . Unit weight of peat is typically lower compared to inorganic soils. Previous researches suggested that for peat water content about 500 %, the unit weight ranges from 10 to 13 kN m^{-3}. A range of 8.3 - 11 kN m^{-3} is common for unit weight of fibrous peat in West Malaysia. The organic content in the range of 50 % to 95 % and the liquid limit was in the range of 200% to 500%.

Edil (2003) summarizes a number of construction options that can be applied to peat and organic soils, namely: excavation-displacement or replacement; ground improvement and reinforcement to enhance soil strength and stiffness, such as by stage construction and preloading, stone columns, piles, thermal pre-compression and preload piers; or by reducing driving forces by light-weight fill; and chemical admixture such as cement and lime. These chemical admixtures can be applied either as deep in situ mixing method (lime-cement columns), or as surface stabilizer.

Chemical admixtures or chemical stabilization always involves treatment of the soil with some kind of chemical compound, which when added to the soil, would result in chemical reaction. The chemical reaction modifies or enhances the physical and engineering properties of a soil, such as, volume stability and strength.

The essential features of deep peat soil stabilisation is that columns of stabilized materials are formed by mixing the soil in place with a 'binder, and the interaction of the binder with the soft soil leads to material which has better engineering properties than the original soil. It is generally recognised that organic matter and low pH of peat in the presence of black humic acid tend to interfere the hydration process, if it is to be stabilised by Ordinary Portland cement. This is possible due to the fact that the acid tends to react with calcium liberated from cement hydrolysis to form insoluble calcium humic acid making it difficult for calcium crystallisation, which is responsible for the for the increase of cement soil strength to take place. Furthermore, the secondary pozzolanic reaction of the cement stabilised peat is retarded due to insufficient silica (SiO_2) and alumina (Al_2O_3) that can react with calcium hydroxide [$Ca(OH)_2$] generated from cement hydration to form secondary calcium silicates, which are responsible for the long term strength gain of the stabilized peat soil.

Study was carried out by Huat et al. (2005) to examine the effect of cement on the unconfined compressive strength of the peat soil sample, namely to examine the effect of cement content and curing period, as well as the influence of organic content on the unconfined compressive strength of the peat soil samples and revealed that increasing the cement content increases the unconfined compressive of the soils samples. Similarly higher strength is obtained from samples that have been cured for

28 days compared with the 3, 7, 14-days cured samples. Bergado (1996) found that pozzolanic reaction can continue for months or even years after mixing, resulting in the increase in strength of cement stabilized clay with the increase in curing time.

Deboucha et al. (2008) conducted a study to stabilise peat soil using cement, bentonite and sand as binder in different ratio and revealed that unconfined compressive strength was increased after stabilisation. Author also found that higher strength was obtained from samples that had been cured for 14 days compared with 7 days cured samples.

2.2 Types of Peats

Peat lands can be divided into two types which are shallow peat wetlands and deep peat wetlands. As for Sarawak, there are about 90% of wetlands are classified as deep peat, which is as deep as 1.5 m to 2.1 m. They have their own properties which are differentiate them from each other.

Tropical peat swamp forests have sequestered carbon dioxide (CO_2) from the atmosphere into the peat up to 24,000 years, and thus reduced the greenhouse effect in the global scale. Peat deposit thickness can exceed 20 m, and the mean peat depth of about 5 m is exceeding that of our boreal peatlands. It has been estimated that if the tropical swamps form about 13% of the global mire area, but the amount of the carbon in tropical peat can form up to one third of the carbon of all mires on our planet. Large part of the plant biomass produced by wet environment adapted peat